Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

CarbonSAFE North Dakota – Early Successes

DOE Award DE-FE0031889

2021 AIChE Annual Meeting

Virtual

November 18, 2021

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North Dakota CarbonSAFE Project Overview

- Performance dates:
  - BP1: September 2020 – August 2022
  - BP2: September 2022 – August 2023

PROJECT TUNDRA

Minnkota Power COOPERATIVE
A Touchstone Energy® Cooperative

EERC
UND UNIVERSITY OF NORTH DAKOTA

U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Industrial Commission of North Dakota
Lignite Research, Development and Marketing Program

CMG COMPUTER MODELLING GROUP LTD.

Schlumberger

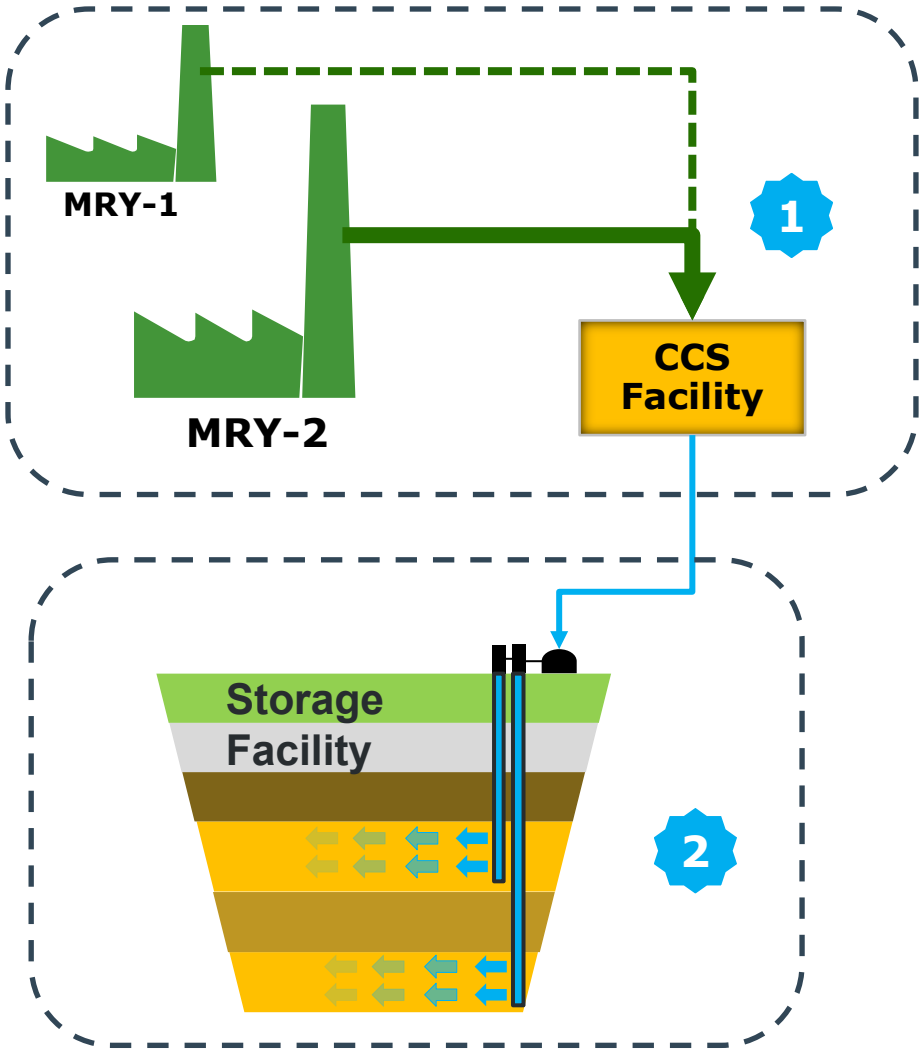
Square Butte ELECTRIC COOPERATIVE

North Dakota CarbonSAFE Phase III: Site Characterization and Permitting

3-year Project

- Geologic characterization
- Lab analysis of rock and fluids
- Geophysical surveying and modeling
- Baseline monitoring (water and soil)
- North Dakota storage facility permit development

Project Tundra Overview



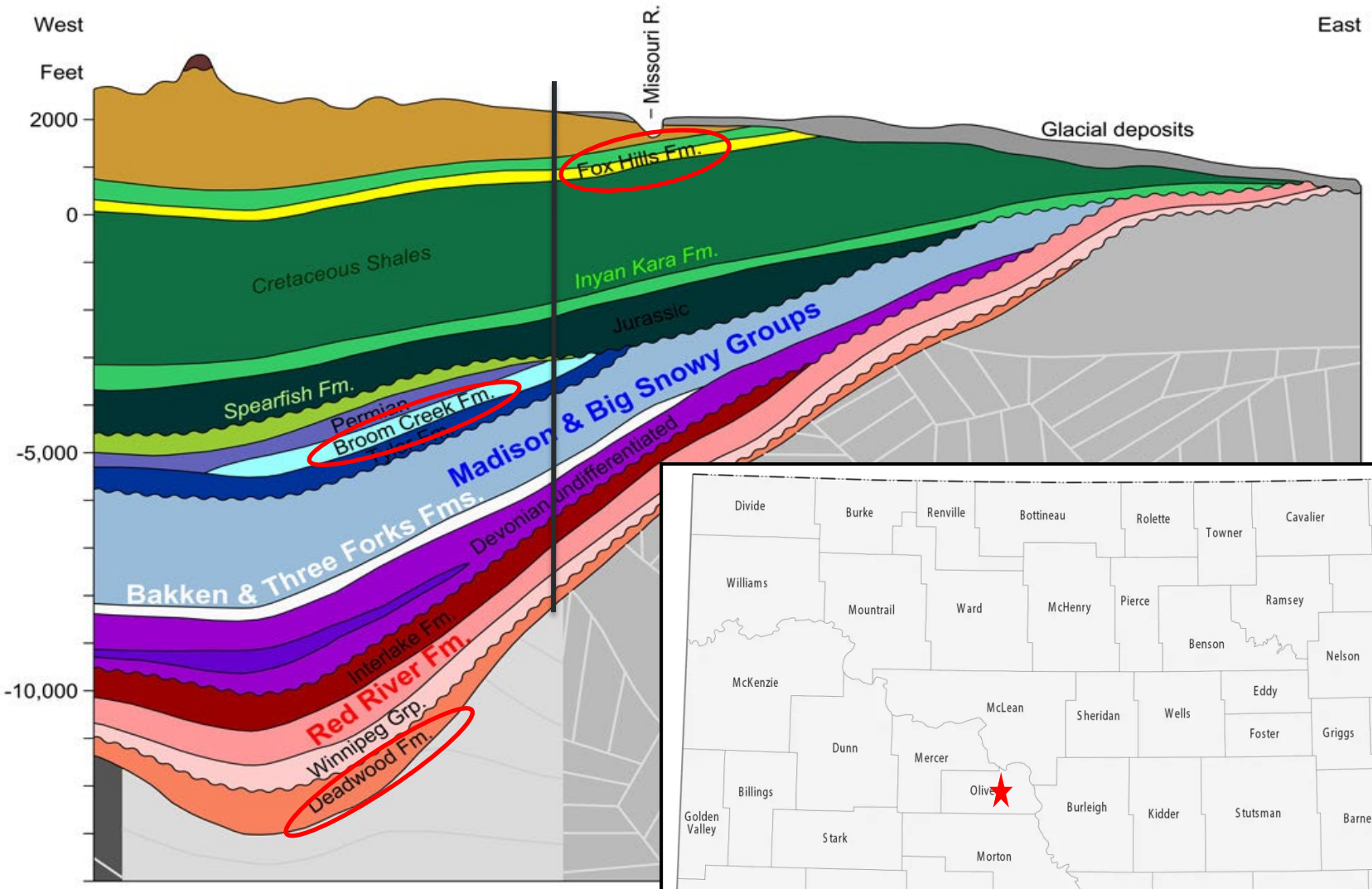
Two Projects in One

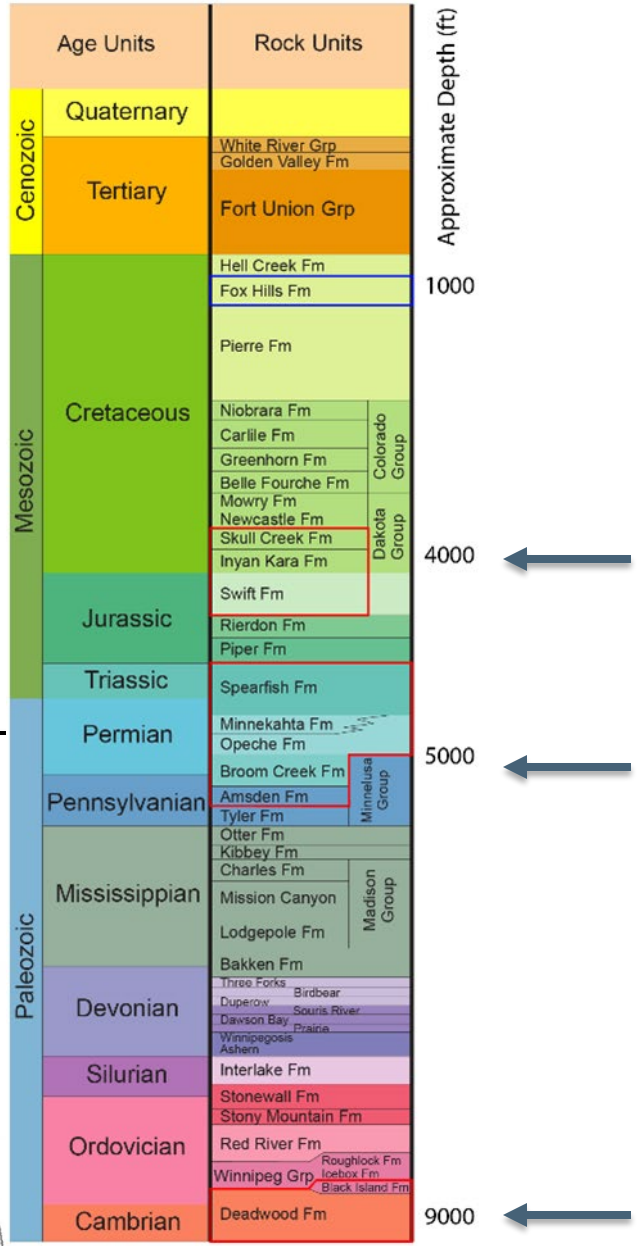
1. **Divert flue gas then separate CO_2** in a carbon capture system that strips out the CO_2 then liquifies under pressure.

2. **Inject CO_2 into storage formation** over a mile below lignite mine.

No impact on the power plant and no impact on its costs.

Project Location





Technical Approach

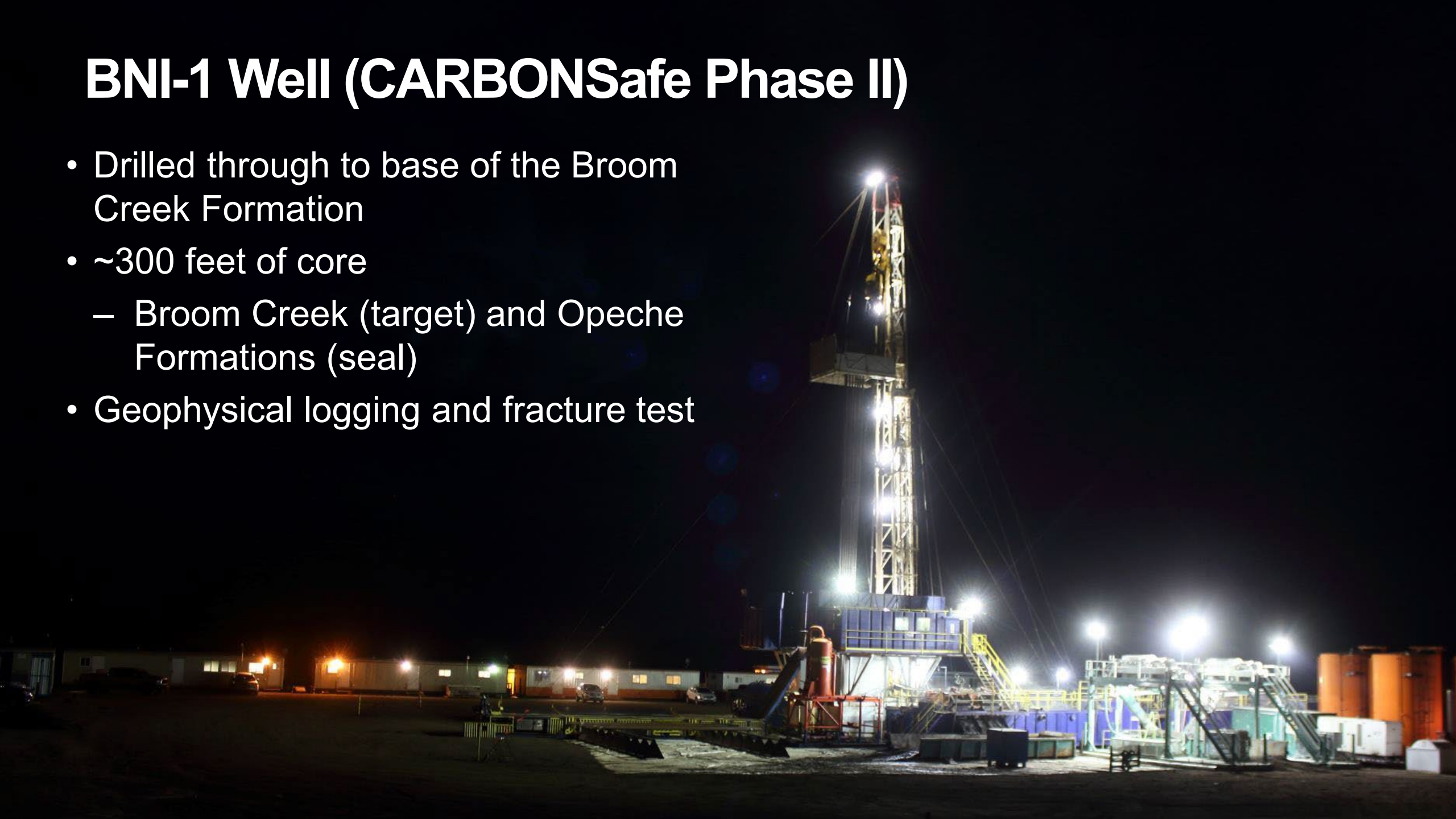
Major NDIC Permitting Requirements	Major Proposed Characterization Activities										
	Core	Logging	Downhole Testing	Lab Testing	Modeling	Simulation	Seismic	Collection	Baseline	Sampling	New Fox Hills Wells
Determine Plume Extent	X	X	X	X	X	X	X				
Determine Pore Space Amalgamation	X	X	X		X	X	X				
Geologic Properties of Injection and Confining Zones	X	X	X	X							
Regional Faulting Assessment	X						X				
Potential for Seismic Activity			X		X		X				
Geologic Maps and Cross Sections		X			X		X				X
Geomechanics of Confining Zones(s)		X	X	X	X						
Identify and Characterize Secondary Confining Zones		X	X		X		X				
Determine Area of Review		X	X	X	X	X	X	X	X		
Baseline Geochemical Data	X			X				X	X		
Baseline Water and Soil Data				X				X	X		


Center, ND
(Pop. 588)
1 mile
J-LOC1 Well
(Strat test)
BNI1 Well
(Strat test)
~5 miles
Milton R. Young
Station
J-ROC1 Well
(Strat test)


J-LOC1 Well
x
CarbonSAFE
Well

BNI-1 Well (CARBONSafe Phase II)

- Drilled through to base of the Broom Creek Formation
- ~300 feet of core
  - Broom Creek (target) and Opeche Formations (seal)
- Geophysical logging and fracture test

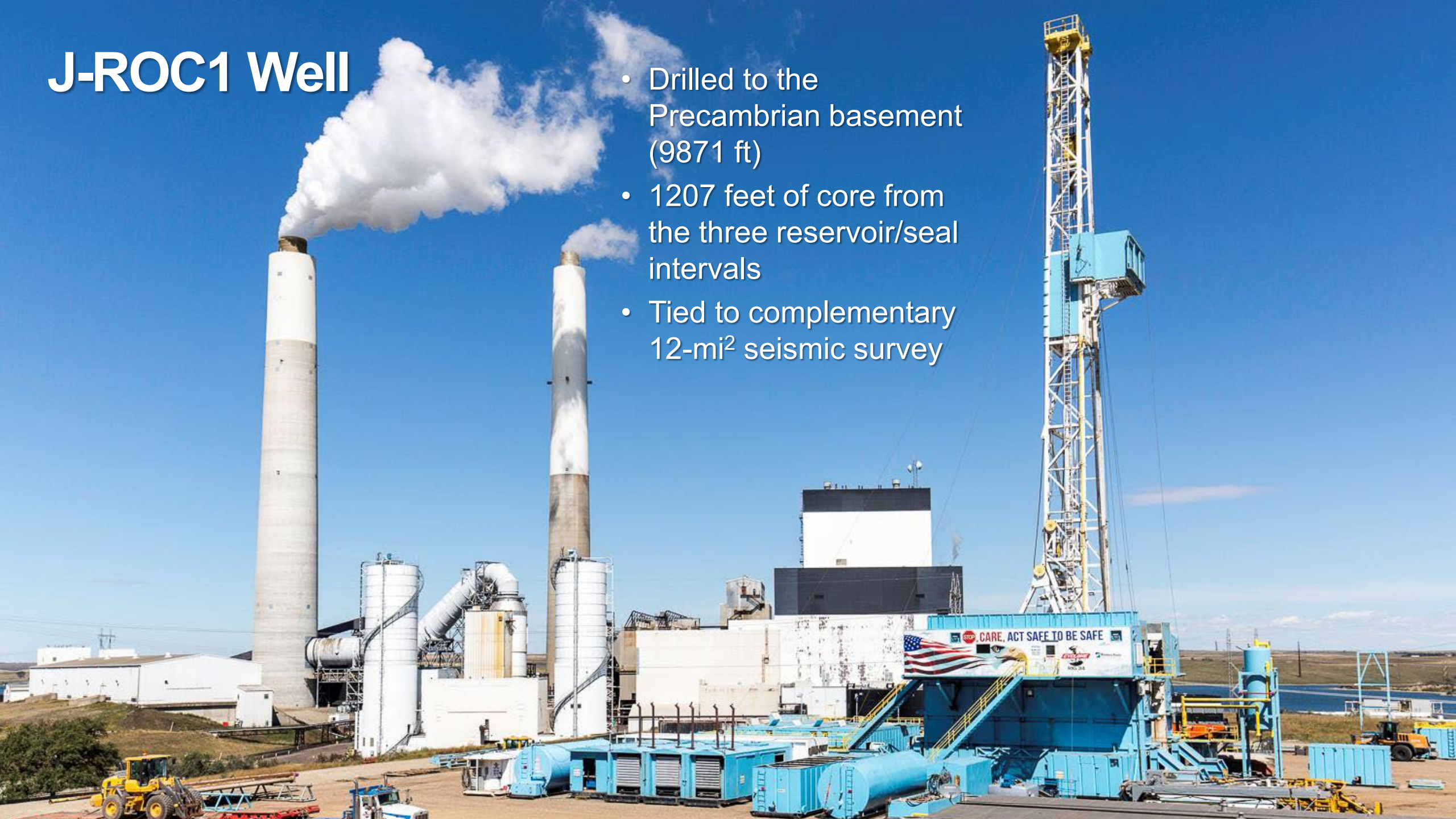


J-LOC1 Well

- Drilled to the Precambrian basement (10,300 feet)
- 1344 feet of core from three reservoir/seal intervals
- Tied to complementary 6-mi^2 seismic survey

Photo courtesy of John Oleksik, EERC

J-ROC1 Well



- Drilled to the Precambrian basement (9871 ft)
- 1207 feet of core from the three reservoir/seal intervals
- Tied to complementary 12-mi^2 seismic survey

Step Rate Injection Tests

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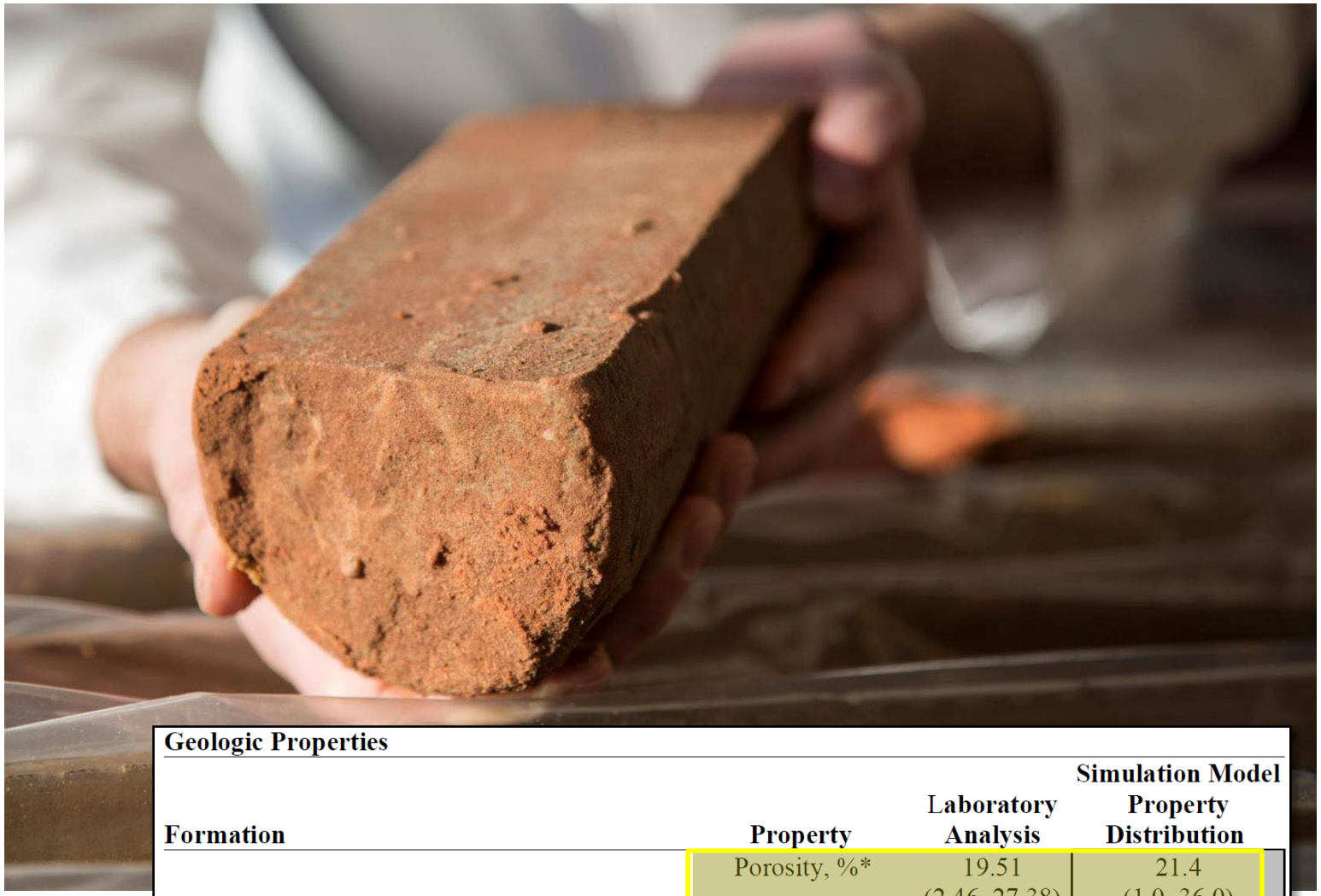
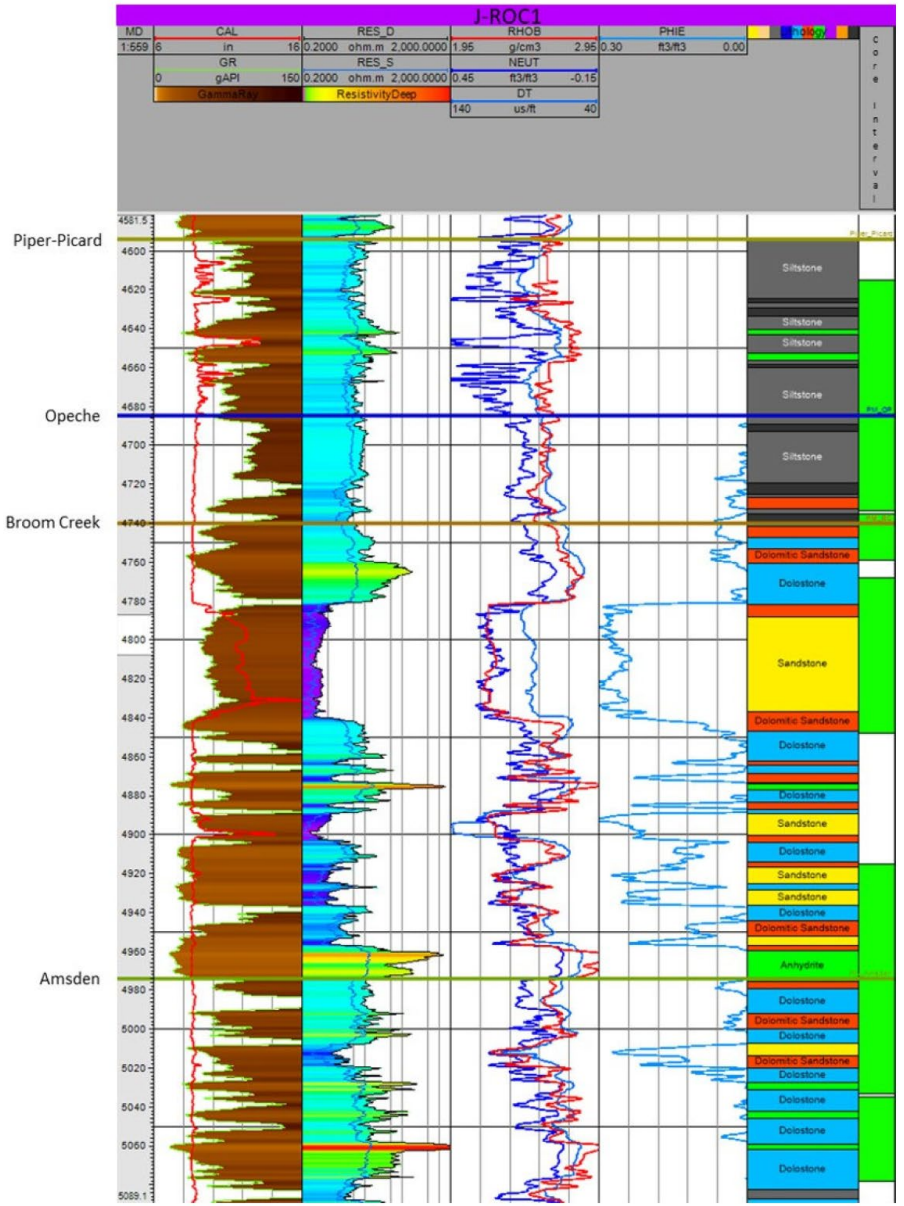




Geologic Properties

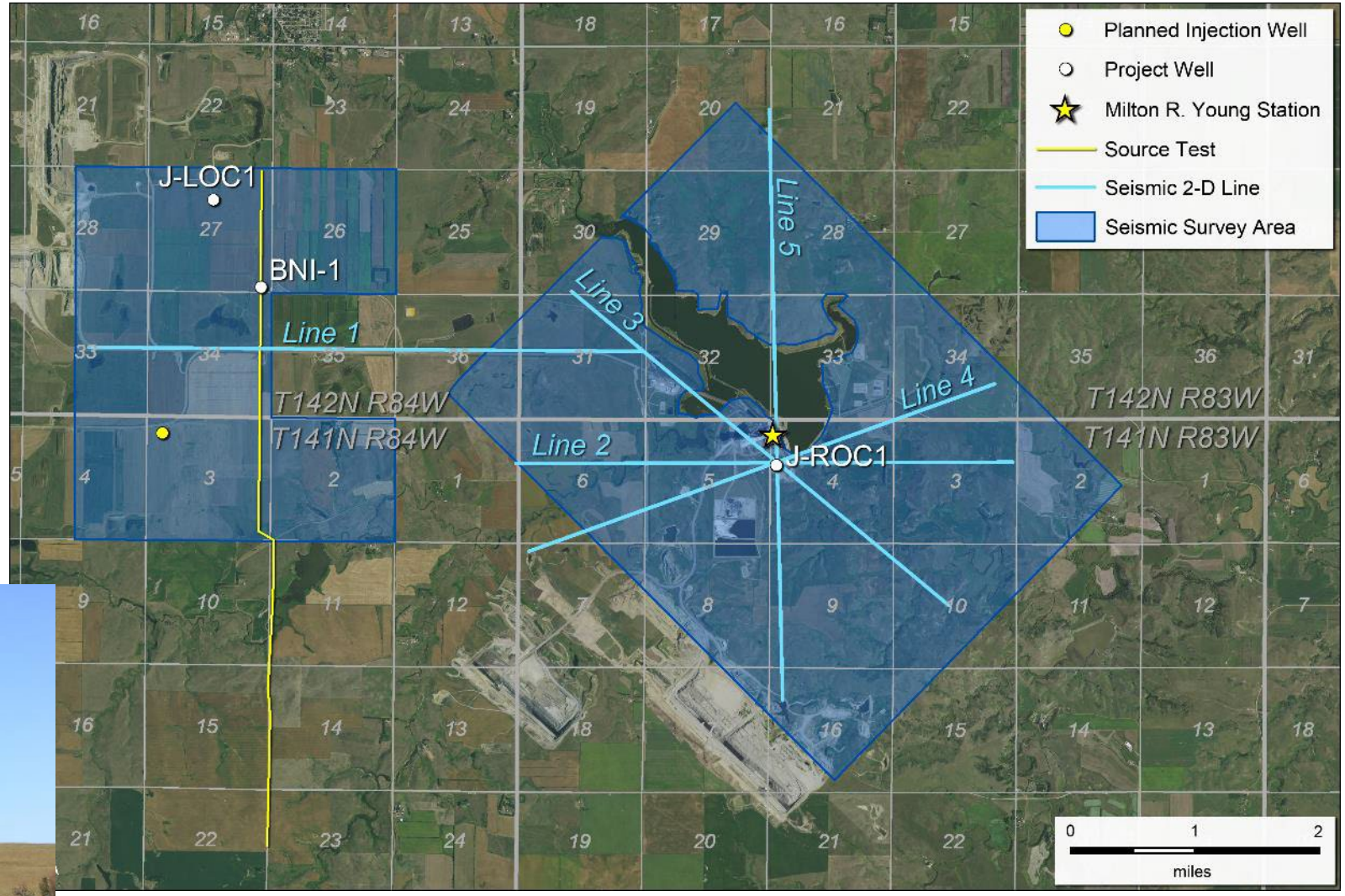
Formation	Property	Laboratory Analysis	Simulation Model Property Distribution
Broom Creek (sandstone)	Porosity, %*	19.51 (2.46–27.38)	21.4 (1.0–36.0)
	Permeability, mD**	69.29 (0.06–2,690)	168.8 (0.0–8,601.1)
Broom Creek (dolostone)	Porosity, %	8.11 (5.48–8.97)	5.8 (0.0–18.0)
	Permeability, mD	0.03 (0.02–0.05)	0.13 (0.0–2,259.6)

* Porosity values are reported as the arithmetic mean followed by the range of values in parentheses.
** Permeability values are reported as the geometric mean followed by the range of values in parentheses.

Seismic Surveys

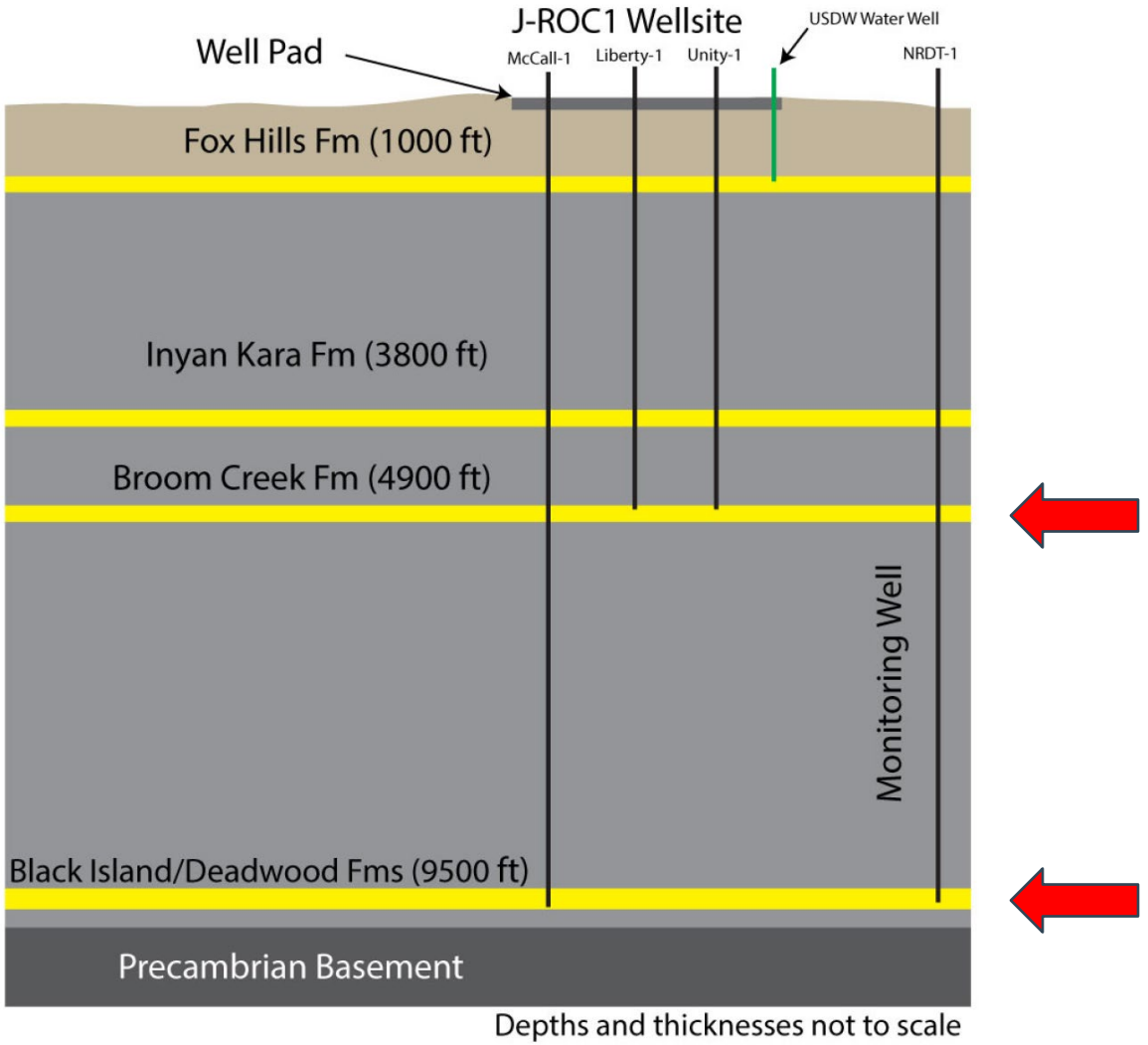
Seismic Data

- **2019**
  - **5-mi** source test line
  - **6.7 mi²** of 3D seismic data
- **2020**
  - **12 mi²** of 3D seismic data
  - **20 mi** of 2D seismic data

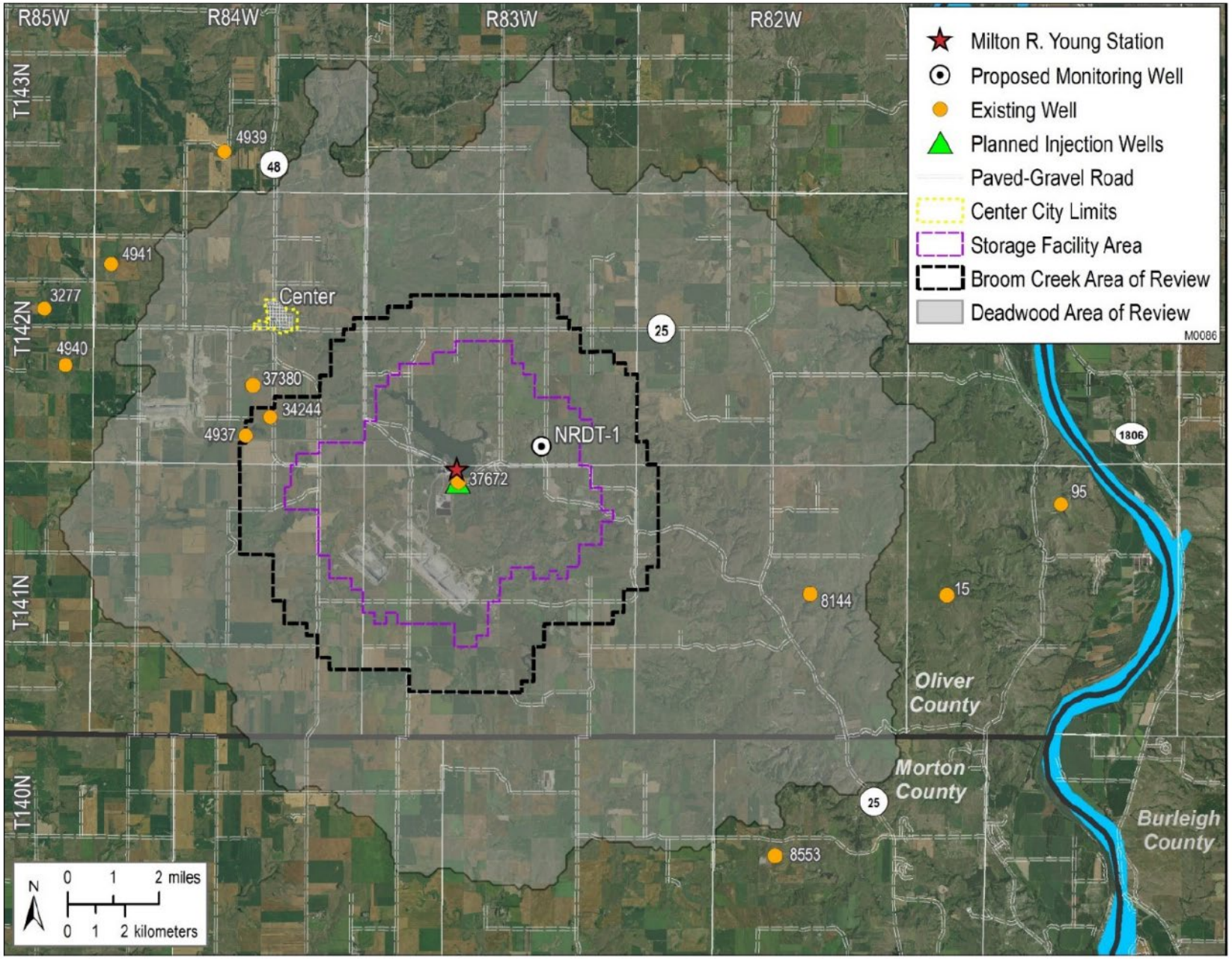


General Project Configuration

- Stacked storage beneath the power plant
- Very short pipeline
- Storage facility permit application for each target horizon



Project Tundra CO_2 Storage Area Map



North Dakota Administrative Code for CO_2 Storage

- Defined timeline for issuing a final decision on a storage facility permit application
- Amalgamation of pore space and procedure to include nonconsenting owners
- Postinjection title transfer (long-term liability)
- Establishment of trust funds to manage the long-term liability

Latest Successes!

- May 28: Two storage facility permit applications submitted (600 pages each).
- September 23: Two draft storage facility permits established (North Dakota permit applications deemed to be complete).
- November 4: 7.5 hours of testimony in front of the North Dakota Industrial Commission to address the permit requests.
- November 16: Requested supplemental material submitted.
- Fingers crossed…final North Dakota permit approval before mid-February.

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THANK YOU

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